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Hierarchical microstructures in metals due to dislocation-mediated plasticity

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Dislocations are highly beneficial line defecs in the crystallographic lattice of metals. They are the carriers of plasticity and their motion is strongly linked to crystallography. During deformation, the dislocation density increases, leading to hardening but also evolution of the microstructure in the metal.

Industrial metals have a hierarchical microstructure. They are polycrystals composed of numerous grains with typical diameters of tens of micrometres. Each grain is characterised by the orientation of its crystal lattice. Initially each grain is a homogenous entity with a single orientation.

As deformation proceeds by dislocation motion, each grain develops significant orientation spreads due to the interaction between the grains; the lattice of initially similarly oriented grains rotate differently (leading to *intergranular* orientation differences) and *intragranular* orientation spread also develops.

The dislocations self-assemble in dislocation boundaries inside each grain with a spacing of a few micrometres. Characteristic patterns of boundaries, typically parallel planar boundaries, form. This pattern varies substantially between grains, leading to different local properties. Finally, a boundary consists of a network of dislocations with a spacing of a few nanometers.

An overview of the evolution of the hierarchical microstructure is presented with emphasis on our understanding of the underlying mechanisms.